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(54) **Apparatus and method for determining boring direction when boring underground**

(57) A guidance module for an underground horizontal boring assembly. The module determines the pitch angle of the boring tool independent of roll using a single accelerometer sensor. The accelerometer sensor has a single sensitive axis which is aligned parallel to, and preferably coaxial with, the longitudinal axis of the boring tool. The accelerometer sensor is calibrated to obtain a temperature offset and a gain compensating gain factor. Data samples are read from the accelerometer sensor while the boring tool is rotating. The temperature is read from the temperature sensor. The data

samples from the accelerometer sensor and the temperature from the temperature sensor are transmitted to a processor. The processor applies simple average filtering to the accelerometer data samples to get an average result, and adjusts the average result for gain. The average result is adjusted for the temperature offset and for the gain compensating gain factor. The average result then can be adjusted for an optional roll angle offset. The pitch angle is determined either from a lookup table or from the arcsin value of the quantity of the average result minus the temperature offset divided by the gain compensating gain factor.

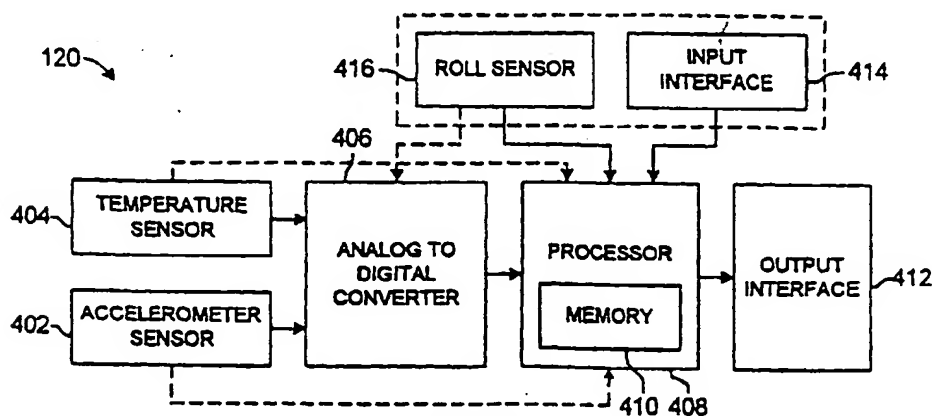


FIG. 4



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EUROPEAN SEARCH REPORT

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IntCl.6)
A	US 4 164 871 A (COLE CHARLES F ET AL) 21 August 1979 (1979-08-21) * abstract * * column 4, line 20 - line 38 * ---	1,19,26, 36	E21B47/022 E21B47/024
A	US 4 361 192 A (TROWSDALE LARRY S) 30 November 1982 (1982-11-30) * column 4, line 28 - line 60 * * column 10, line 6 - line 23 * -----	1,19,26, 36	
			TECHNICAL FIELDS SEARCHED (IntCl.6)
			E21B
-The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 27 April 1999	Examiner HOEKSTRA, F
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document</p>			



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CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing more than ten claims.

- ☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid, namely claim(s):
- ☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

- ☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.
- ☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.
- ☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:
- ☒ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

1-59



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**LACK OF UNITY OF INVENTION
SHEET B**

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The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. Claims: 1-59

Device and method for determining boring tool pitch angle by processing accelerometer pitch data samples.

2. Claims: 60-65

Method for compensating process signal gain.

ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.

EP 97 30 9843

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

27-04-1999

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4164871 A	21-08-1979	AU 510311 B	19-06-1980
US 4361192 A	30-11-1982	NONE	